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Understanding the Magnitude and Spread of HIV/AIDS Epidemic in Sub-Saharan Africa: Evidence from the Demographic and Health Surveys and AIDS Indicator Surveys

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ABSTRACT

We describe how HIV seroprevalence data collected in national population-based surveys, such as the Demographic and Health Surveys and AIDS Indicators Surveys, have helped improve understanding of size and spread of the epidemic in sub-Saharan Africa. We describe the methods used to collect nationally-representative data on HIV seroprevalence, compare survey-based estimates with sentinel surveillance-based estimates, and evaluate survey-based estimates for potential bias due to non-response and due to exclusion of non-household populations. Data are from 14 nationally-representative household surveys with HIV testing, conducted during 2003-2006. Dried blood spot samples were collected (venous blood in Uganda) and analyzed for HIV using standard laboratory and quality control procedures and internationally accepted ethical standards. HIV test results were linked anonymously to the characteristics and risk behaviors of adult respondents. We find that survey-based estimates of HIV prevalence tend to be lower than sentinel surveillance-based estimates. Analysis of non-response bias indicates that although non-tested males and females tend to have higher predicted HIV prevalence than those tested, overall effects of non-response on the observed national HIV prevalence estimates are insignificant. Our analysis also shows that exclusion of non-household population groups in the surveys is likely to have a minimal effect on the observed HIV estimates.

BACKGROUND

The HIV/AIDS epidemic is one of the largest public health crises of the 21st century. While the epidemic has spread over the past two decades, a cure or vaccine for HIV has remained elusive. Reliable data on HIV prevalence in the general population are essential for an effective response to the epidemic and its consequences. In countries with generalized epidemics, national estimates of HIV prevalence levels and trends in the adult population are generally derived indirectly from HIV surveillance among pregnant women attending selected antenatal clinics (WHO and UNAIDS 2005; WHO and UNAIDS 2003; Saphonn et al. 2002). Recently, HIV seroprevalence data have also been collected in national population-based surveys, such as the Demographic and Health Surveys and AIDS Indicators Surveys. Such surveys have enabled direct estimates of population HIV prevalence.

The HIV prevalence estimates have come under increased scrutiny in recent years and some countries have revised their estimates downward as more reliable data have become available. A good example is a substantial downward adjustment of estimated number of HIV-infected people in India in 2007, from 5.7 million to 2.5 million. Similar downward adjustments in HIV prevalence estimates have also been made for several countries in sub-Saharan Africa. As a consequence, UNAIDS and WHO have recently lowered the global estimate of number of HIV-infected people from 39.5 million in 2006 to 33.2 million in 2007 (UNAIDS and WHO 2007). Moreover, recognizing the uncertainty in the estimation of HIV, UNAIDS and WHO provide a confidence interval around its global estimate (30.6-36.1 million). While some imprecision in the global total may not make a substantial difference in international attention to the epidemic or resource allocations, the extent of imprecision may vary greatly by country and may have major consequences for the local public health response.

Since the late 1980s, country-specific HIV prevalence estimates in countries with generalized epidemics have been derived from data collected at health facilities providing antenatal care for pregnant women (WHO and UNAIDS 2005). Pregnant women are considered to be a good proxy for the general population, and this population is accessible through routine antenatal care visits, where blood is generally collected for other tests. However, HIV prevalence estimates based on pregnant women may be affected by biases which can lead to over-estimation of HIV prevalence among the general population (Boerma et al. 2003). Pregnant women are an imprecise proxy for the general population if pregnancy occurs more frequently at younger ages, and among rural, poorer women. Pregnant women are sexually active and may have been exposed to HIV, unlike their non-sexually active peers. However, HIV-infected women may be physiologically less likely to become pregnant, which can lead to an underestimation among women of same age in the general population. Furthermore, ANC coverage is not universal in all countries, the ANC surveillance sites often cover a limited, more urbanized geographic area, and finally the ANC surveillance data do not provide information on men.

Given the increasing need for more precise data on the HIV epidemic, the population-based Demographic and Health Surveys (DHS) began to include HIV testing of adult women and men in 2001. Population-based surveys have many advantages: they provide representative estimates for both women and men, for geographic regions, and by age groups (Mishra et al. 2006). Population surveys offer another significant advantage, the linkage of HIV status with individual respondent and household characteristics. The linked surveys allow for the analysis of behavior, knowledge, and background characteristics as they relate to HIV status. Since 2001, some three dozen population-based surveys with HIV testing have been or are being carried out under the Demographic and Health Surveys project (www.measuredhs.com).

A major challenge for the surveys is potential bias due to non-response. Some eligible respondents may be absent at the time of the survey while others may be incapacitated or chose not to participate. The survey estimates of HIV prevalence may be biased to the extent the non-responders have different HIV prevalence levels than the responders. Another major challenge is exclusion of non-household population groups. Again, the survey estimates may be biased to the extent people residing in institutions (such as brothels, prisons, hostels, military/police barracks) or those living on the street have different HIV prevalence levels than those living in households and included in the survey sample.

WHO/UNAIDS have published annual estimates of HIV prevalence among adults age 15-49 since 1990. ANC data have been the primary source of HIV prevalence data used to model these population estimates. In most countries the survey-based estimates of HIV prevalence are found to be lower than the surveillance-based estimates published by the UNAIDS. The new data sources have led to the revision of current HIV prevalence estimates. In most cases where the revisions have been substantial, the prevalence estimates have been revised downward, with the notable exception of Uganda where the survey estimate was higher than the surveillance-based estimate, which was subsequently revised upward (UNAIDS 2006).

Table 1 presents HIV prevalence estimates for selected countries where a DHS or an AIDS Indicator Survey (AIS) with HIV testing was conducted during 2003-2005. A comparison of the ratios of the UNAIDS estimates for the three time points over the DHS estimate illustrates this downward revision (with the exception of Uganda). In 11 of the 12 countries, the 2005 ratio was between 0.9 and 1.1, indicating the shift of UNAIDS estimates to almost perfectly matching the DHS/AIS estimates. In 6 of the 12 countries, the most recent UNAIDS estimate was identical to the DHS/AIS estimate.

<Table 1 about here>

In this study, we describe how HIV seroprevalence data collected in national population-based surveys have helped improve understanding of the size and spread of the epidemic. We describe the methods used to collect nationally-representative data on HIV seroprevalence, compare the survey-based estimates with ANC surveillance-based

estimates, and evaluate the survey estimates for potential bias due to non-response and due to exclusion of non-household population groups in the surveys in selected countries.

METHODS

This study uses data from 14 nationally-representative surveys of adult women and men, conducted during 2003 and 2006. Eleven of these surveys were Demographic and Health Surveys: Burkina Faso, Cambodia, Cameroon, Ethiopia, Ghana, India, Kenya, Lesotho, Malawi, Rwanda, Zimbabwe; and three were AIDS Indicator Surveys: Cote d'Ivoire, Tanzania, Uganda. All these surveys included HIV testing.

In most surveys, nationally-representative samples of women age 15-49 and men age 15-59 were tested for HIV. The only exceptions are Uganda where women age 15-59 were tested; Tanzania, Cote d'Ivoire, and Cambodia where men age 15-49 were tested, and India, Kenya, Malawi, and Zimbabwe where men age 15-54 were tested. The 2004/05 Uganda survey also tested HIV status among children under age 5. In the 14 countries included in this analysis, the numbers eligible for HIV testing ranged from 3,305 males (15-59) and 3,758 females (15-49) in Lesotho to 64,175 males (15-54) and 62,182 females (15-49) in India.

In the following, we first describe HIV testing procedures in the population-based surveys. Next, in five of the countries (Ethiopia, Kenya, Malawi, Tanzania, and Uganda), we compare HIV prevalence estimates from the population-based surveys to those derived from antenatal surveillance of pregnant women. For evaluating potential bias due to non-response in all 14 surveys, we estimate HIV prevalence among non-responding adults based on multivariate statistical models of HIV for those who were interviewed and tested, using a common set of predictor variables. Finally, in two of the countries (Cambodia and India), we examine potential bias due to exclusion of non-household population groups in the surveys by using the size of non-household population in the national census population and by assuming different levels of HIV prevalence in the non-household population.

HIV testing in Demographic and Health Surveys

General survey methodology

The DHS program has conducted more than 200 national household surveys in more than 70 developing countries worldwide since 1984. The challenges in designing and implementing DHS surveys in developing-country settings, as well as lessons learned from more than 20 years of experience, are discussed elsewhere (Vaessen et al. 2004). It is well recognized that all aspects of survey planning and implementation, such as sample design, developing and field-testing survey instruments, training of survey personnel, and careful supervision of data collection and processing, are critical in collecting high-quality data in such surveys (Cleland and Scott 1987).

Of particular importance for the interpretation of HIV prevalence results from the surveys is the sampling methodology. The DHS selects random sample clusters from a national sampling frame, usually from the national population census. Within the selected clusters, a full listing of all households is done prior to the DHS and a systematic random sample of households is taken. During the main fieldwork eligible women and men, usually aged 15–49 and 15–59 years respectively, are selected for HIV testing. An individual is only considered absent after three callback visits.

In order to obtain reliable national HIV estimates disaggregated by sex and urban/rural residence, a representative sample of at least 3,000 households is required. If, on average, there is one eligible male and one eligible female in each sample household and if 10% of the eligible males and females do not participate in the survey, this yields a final sample of roughly 5,400 tested adults. For a population with an estimated prevalence rate of 5%, such a sample would provide a 95% confidence interval of 4.3–5.7% at the national level. Larger sample sizes are required if HIV prevalence is lower or if further disaggregation of HIV estimates is desired.

Specimen collection

In most surveys, HIV testing is done using dried blood spot (DBS) samples collected on special filter paper using capillary blood from a finger prick. The only exception was the 2004/05 Uganda AIS where venous blood was used. Use of capillary blood for HIV testing is a preferred method in population-based surveys because obtaining samples from a finger prick is considered a less painful, less invasive procedure than drawing venous blood samples. Moreover, DBS specimens are easier to collect, store, and transport than venous blood samples.

Three to five preprinted circles on the bloodspot collection card are filled using blood drops. Samples collected on filter paper are allowed to dry overnight in a drying box with desiccant and a humidity indicator card, after which the field worker packs the samples in individual zipper-locked bags with desiccant and a humidity indicator card. Appropriately packed DBS samples are stored in an insulated box and transported to a central laboratory for HIV testing (ORC Macro 2005a).

Laboratory testing

A well-recognized central laboratory is identified to process the DBS samples for HIV testing, after carefully assessing its reputation, experience, and capacity. Prior to the start of the survey field operations, the central laboratory is required to provide evidence of its ability to produce valid antibody test results from DBS samples with the two different assays chosen for the testing. The testing follows a standard laboratory algorithm designed to maximize the sensitivity and specificity of HIV test results.

The standard testing algorithm uses two different HIV antibody ELISAs, based on different antigens. All discordant samples that are positive on the first test and negative

on the second test are subjected to a second round of testing using both the ELISAs. Discordant samples from the second round of testing are classified as "indeterminate". The "indeterminate" samples are subjected to a Western-Blot confirmatory test. The Western-Blot result is considered final for the indeterminate samples. These steps are repeated for 5–10% of randomly selected samples that tested negative on the first test (ORC Macro 2005b).

During the course of sample processing, the laboratory adheres to an approved quality assurance and quality control plan with both internal and external components. For external quality assessment, a subset of DBS samples (usually about 5%) from the survey specimens is submitted to an outside reference laboratory for retesting.

Ethical issues

The general health interview is conducted prior to the blood collection. Before collecting blood samples for HIV testing, the participant selected is asked to provide informed voluntary consent to the testing. A written statement describing the procedures to be used in testing and the potential benefits and risks is read to each individual respondent. The respondents are given an opportunity to ask any questions about the survey that may help them decide whether or not they want to participate. The interviewer records the respondent's decision on the questionnaire and signs the questionnaire affirming that he/she has read the statement and that the decision recorded is the one given by the respondent (ORC Macro 2005a).

To protect the confidentiality of the participants, the data are "anonymized" by scrambling the cluster and household numbers associated with each participant in such a way as to make it impossible to associate an individual data record with a particular place and household. HIV test results are linked to data from the questionnaires using barcodes only after the identity codes have been scrambled and after the files containing the original identity codes have been destroyed. Because the test results cannot be linked to a respondent's identity, there is no possibility of inadvertent disclosure. Any paper records that might in any manner compromise the confidentiality of the respondents, such as the pages of the questionnaires containing barcodes, are also destroyed.

All HIV testing procedures are reviewed by the ethical review boards of Macro International Inc. (a U.S.-based company that provides technical assistance to DHS surveys around the world), the host country, and any other implementing partners.

All survey participants are given country-specific informational brochures on HIV/AIDS in their local language. Each eligible respondent for HIV testing, whether he/she accepts testing or not, is also given information on the nearest facility providing voluntary counseling and testing (VCT) services and is encouraged to use these services. If VCT services are not free, eligible participants are given a voucher to go to the closest VCT facility for free HIV counseling and testing if they so desire. In countries with inadequate VCT facilities, efforts are made to improve access to VCT services or to provide mobile

VCT teams to follow-up after the survey interview to counsel and test willing survey respondents.

In addition to protecting confidentiality and providing information and VCT services, it is important to ensure the safety of both the respondents and survey teams. DHS has developed procedures and guidelines for safety in the collection and handling of biological specimens and for disposal of biohazards (ORC Macro 2005a).

Antenatal care (ANC) surveillance surveys

ANC surveillance systems have been in place for a number of years in most countries with generalized epidemics. In the five countries included in the analysis of ANC/DHS comparison, the latest round of available surveillance estimates were used. The ANC surveillance sample sizes for the five countries included in this study range from 8,953 in Malawi to 28,247 in Ethiopia. The sample sizes reflect the total population size of the country. These data collection systems provide regular information to monitor HIV prevalence. ANC surveillance data from the five countries in this analysis followed the methodology described in the WHO guidelines (WHO, UNAIDS, and CDC 2003). The sampling design for ANC site selection was specific to each country's surveillance system, and the sites were distributed between urban and rural areas. The number of surveillance sites in each country depended partly on the percentage of the general population who use ANC services, as well as the total population of the country. For example, in Ethiopia where ANC coverage is relatively low and the population is large and disparate, a total of 88 sites throughout the country participated in the ANC surveillance survey. In Malawi, with comparatively high ANC coverage and a small population, a total of 19 ANC sites were included in the surveillance survey.

Pregnant women who presented at the sentinel sites for their first prenatal visit were generally eligible for participation in the surveys. The target sample size for each ANC facility was recommended to be between 200 and 400 women. Women were selected consecutively until the target sample size was reached. At the end of a three-month period, the sampling had to stop regardless of whether the target was reached. An exception was Ethiopia, where the target sample size was 250 for rural sites, and 400 for urban sites. Because of the low ANC coverage in the country, the data collection period was extended to 20 weeks for the rural sites, and those that were unlikely to meet the target number collaborated with satellite sites. In Uganda, target sample size ranged from 300 to 800 in 19 sites. In Kenya, target sample size ranged from 200 to 400 in 43 sites. In the ANC surveys, the participants were generally not informed of their inclusion in the surveillance sample. Participants had their blood samples taken routinely for other tests as part of their ANC visit, and the same samples were used for HIV testing. Because the HIV test results were not linked to patient records, informed consent was not required according to the WHO guidelines (WHO, UNAIDS, and CDC 2003).

Comparison of ANC and DHS/AIS estimates

A GIS-based methodology was used to identify the DHS/AIS clusters which were located within a reasonable distance of the ANC sites. Sample households within these clusters were expected to represent the catchment population of the ANC site.

A list of ANC surveillance facilities were obtained from the published sentinel surveillance reports for each country. Locations of the health facilities were georeferenced to the town or village where the site was located, or the facility itself. In Ethiopia, the locations of the health facilities were provided by the Ministry of Health. The locations of ANC sites in Tanzania were georeferenced to corresponding towns and villages from the WHO/HealthMapper database. Missing facilities were matched to town or village locations manually, or by obtaining GPS coordinates in collaboration with the National AIDS Control Programme. In Malawi, sentinel sites were matched to the facility GPS locations from the Ministry of Health Update of the Census of Health Facilities. In Uganda, the sentinel sites were located in the WHO/HealthMapper database (version 4.2), and were updated in collaboration with the Ministry of Health. The ANC sites in Kenya were georeferenced by matching the sentinel sites to the list of health facilities in the KEMRI/Wellcome Trust database and the WHO/Service Availability Mapping database. All coordinates were projected to corresponding Universal Transverse Mercator (UTM) zones for each country.

The georeferenced locations of the ANC surveillance sites were then plotted with the DHS/AIS cluster locations. The distance from each DHS/AIS cluster to the nearest ANC site was calculated as Euclidian or as the crow flies distance. The distances were calculated in kilometers using ArcView 9.1 (ESRI 2006). For each ANC site, the DHS clusters within 15 km were identified. The 15 km radius was used as an approximation of the geographic catchment area of the ANC site. The DHS/AIS sample clusters typically follow the distribution of the population in the country, whereas the ANC sites tend to be unevenly distributed across the country, typically located near major roads or in towns.

After identifying the DHS/AIS clusters within 15 km of an ANC site in each country, HIV prevalence was tabulated for a set of key background characteristics which were expected to match the sample in the ANC surveillance surveys. For example, currently pregnant women in the DHS/AIS clusters in the catchment area of an ANC site are expected to be similar to pregnant women captured in the ANC surveillance data in years where the two surveys overlap. Women who gave birth in the last three years, and those attended ANC in the last three years are expected to be similar to women included in the ANC surveillance if the time period for data collection was later in the case of the DHS/AIS. The DHS/AIS sample size for currently pregnant women in clusters in the ANC catchment area tends to be small, which may lead to a less precise HIV estimate for these women. The inclusion of all women who gave birth and those attended ANC in the last three years generally yields a larger sample size and is expected to provide more precise estimates. In the case of ANC surveillance surveys, information on previous births (other than parity) or previous ANC care was not available.

Analysis of bias due to non-response in the DHS/AIS surveys

To estimate the extent of non-response bias and its potential impact on the observed HIV rates in the five countries with linked data, all eligible respondents were divided into four groups: (1) interviewed and tested; (2) not-interviewed but tested; (3) interviewed, not-tested; and (4) not-interviewed, not-tested.

To evaluate the effect of non-response bias on the survey estimates, HIV prevalence is predicted among the two non-responder groups (3 and 4) based on multivariate models of HIV for those who were tested, using a common set of predictor variables. A logistic regression model is used, after accounting for clustering in the survey design, to calculate predicted HIV prevalence separately for the "not-interviewed, not-tested" and "interviewed, not-tested" groups. Predictions for the "not-interviewed, not-tested" group are based on a limited set of variables (only from the household questionnaire), but predictions for the "interviewed, not-tested" group additionally use several individual socio-demographic and behavioral characteristics of the respondents, as collected in the survey.

Variables for predicting HIV prevalence in the "not-interviewed, not-tested" group included age, education, wealth index, residence, and geographic region. Additional variables for predicting HIV in the "interviewed, not-tested" group included: marital status; childbirth in last five years (women only); work status; media exposure; ethnicity; religion; circumcision (men only); STI or STI symptoms in the last 12 months; alcohol use at last sex in the last 12 months; number of sex partners in the last 12 months; cigarette smoking/tobacco use; age at first sex; number of lifetime sexual partners; number of sexual partners in the last 12 months; condom use at last sex in the last 12 months; higher-risk sex (sex with a non-marital, non-cohabiting partner) in the last 12 months; knowledge of prevention methods (abstinence, being faithful, and condom use); attitudes toward people living with HIV (PLHIV); woman's ability to negotiate safer sex with spouse; woman's participation in household decision-making (women only); number of medical injections in the last 12 months; duration of stay in current place of residence; number of times slept away in the last 12 months (men only); away (from usual place of residence) for more than one month in the last 12 months (men only); and previously tested for HIV. The list of additional variables used varied slightly from country-to-country, depending on the availability of information.

Multivariate analyses used STATA version 9.0. All analysis was carried out separately for males and females for each of the five countries with linked data. Adjusted HIV prevalence was calculated as a weighted average of observed prevalence among those who were tested and predicted prevalence in the two groups of non-tested respondents. Sampling weights were applied in accordance with standard DHS procedures. We used HIV sampling weights for the tested, individual sampling weights for the "interviewed, not-tested", and household sampling weights for the "not-interviewed, not-tested" groups, respectively.

Analysis of bias due to exclusion of non-household population

In two countries, India and Cambodia, we examined potential impact of excluding non-household population groups on the survey estimates of HIV prevalence for adults age 15-49. India and Cambodia were chosen for this analysis both because the information on the size of non-household population was readily available and because the bias due to exclusion of non-household population was expected to be greater in countries with concentrated epidemics.

We obtained national estimates of the size of household population, size of non-household population (including both institutional and street population), total population, the annual population growth rate, and the proportion of adults age 15-49 in the total population in each country. In India these data were obtained from the 2001 Census (Registrar General of India, 2001); and in Cambodia from the 2004 Inter-Censal Survey (Government of Cambodia, 2005). Using the annual growth rate, the household, non-household, and total population sizes were projected to the DHS survey year. Next, using the proportion of adults in the total population, numbers of adults in the household, non-household, and total population were estimated for the survey year. For the survey estimate of HIV prevalence in the household population, we used the non-response-adjusted estimates of national HIV prevalence among all eligible adults (15-49) living in households (0.29% in India and 0.64% in Cambodia). We then used different assumptions about the proportion of adults in the non-household population and the level of HIV prevalence in the non-household population to estimate overall HIV prevalence among all adults in each country (accounting for both non-response in the household surveys and exclusion of non-household population groups).

We estimated the potential impact of excluding non-household population groups under the following three scenarios:

Scenario A (baseline): Proportion of adults (15-49) in non-household population is same as in the census population; and the HIV prevalence among non-household adults is same as the non-response-adjusted prevalence for all eligible adults in the survey.

Scenario B: Proportion of adults (15-49) in non-household population is 66.67%; and the HIV prevalence among non-household adults is 10-times that of the non-response-adjusted prevalence for all eligible adults in the survey.

Scenario C: Proportion of adults (15-49) in non-household population is 75.00%; and the HIV prevalence among non-household adults is 20-times that of the non-response-adjusted prevalence for all eligible adults in the survey.

RESULTS

Patterns of HIV prevalence by sex and urban/rural residence

Table 2 presents HIV prevalence rates by sex and urban/rural residence for the 14 countries. Total HIV prevalence in these countries ranges from less than 1% in India and Cambodia to 23.2% in Lesotho. Despite large HIV prevalence differences among the surveys, fairly consistent patterns of HIV infection are observed by sex and urban/rural residence. In all 14 countries, HIV prevalence is higher in urban areas than in rural areas. The urban/rural HIV prevalence ratio ranges from 1.07 in Zimbabwe and 1.15 in Ghana to 3.25 in Cambodia, 3.39 in Rwanda, and 8.27 in Ethiopia. HIV prevalence is considerably higher among women than among men in all countries except India where the prevalence is lower among women, and Burkina Faso and Cambodia where the sex differences are negligible. The female-male HIV prevalence ratio is highest in Cote d'Ivoire and Ethiopia where women are more than twice as likely to be infected as men.

<Table 2 about here>

Fairly consistent age patterns of HIV infection emerge from the surveys. In almost all countries, HIV prevalence among women is consistently higher than among men at younger ages, with a cross over occurring during the late thirties or early forties (data not shown).

Comparison with ANC surveillance estimates and DHS/AIS estimates

In three of the five countries in this analysis, DHS/AIS survey estimated HIV prevalence among women age 15-49 to be lower compared to HIV prevalence based on ANC surveillance data (see Table 3). In Ethiopia, the ANC estimate was about three-times the estimate obtained in the DHS. The ANC estimates were also higher for Malawi and Tanzania than the DHS/AIS estimates, but in Uganda, where the epidemic is thought to have peaked (Stoneburner and Low-Beer, 2004), the latest ANC surveillance survey estimated HIV prevalence at 6.0 percent, lower than the DHS estimate at 7.5 percent. Also in Kenya, the ANC surveillance estimate (7.5 percent) was lower than the DHS estimate (8.7 percent). Comparing ANC and DHS/AIS estimates in urban and rural areas revealed similar patterns in that HIV prevalence was higher in urban areas in all countries in both the data sources.

<Table 3 about here>

Table 4 compares ANC surveillance survey estimate of HIV prevalence among women with DHS/AIS estimates for currently pregnant women, women who gave birth in last three years, and those who gave birth in last three years and attended ANC for their last birth. Comparisons are made separately for all women in the DHS/AIS sample and with women living in sample clusters within 15 km of the nearest ANC surveillance site.

In all five countries, HIV prevalence was higher among women who lived in a community within 15 km of the nearest ANC surveillance site than among all women included in the DHS/AIS survey. This may be because ANC sites tend to be more representative of urban areas where HIV prevalence is higher. In four of the five countries, Kenya, Malawi, Tanzania, and Uganda, the DHS/AIS estimate of HIV prevalence among women in the ANC catchment areas was greater than the estimate from the ANC surveillance surveys. In the fifth country, Ethiopia, the DHS estimate in the ANC catchment areas was much closer (4.3%) to the ANC surveillance survey estimate (5.3%) than the DHS national estimate for all women (1.9%). These results indicate that in all five countries, DHS/AIS estimates for women in the catchment areas of ANC surveillance sites were similar or higher than the corresponding estimates for women included in the ANC surveillance surveys.

<Table 4 about here>

In all five countries, women who were pregnant at the time of the DHS/AIS survey had lower HIV prevalence than those who were not pregnant. In all five countries, HIV prevalence was also lower among women who gave birth in the three years preceding the DHS/AIS survey than among those who did not. However, there was no clear pattern by receiving ANC for last birth. In two of the five countries, Ethiopia and Kenya, HIV prevalence was higher among women who gave birth in the last three years and received ANC for their last birth than among women who did not receive ANC or did not give birth in the last three years; but in the other three countries, Malawi, Tanzania, and Uganda, the pattern was reversed. The patterns in HIV prevalence by pregnancy status, child birth experience, and receiving ANC for women in 15 km catchment areas of ANC surveillance sites were generally similar to those for nationally-representative samples of women included in the DHS/AIS surveys, with the exception of Tanzania and Uganda where currently pregnant women in the ANC catchment areas had somewhat higher HIV prevalence than those who were not pregnant.

A comparison of ANC surveillance survey estimates with DHS/AIS estimates for women who gave birth in the last three years and received ANC for their last birth in the 15 km catchment areas of the ANC surveillance sites shows no clear pattern. In two of the five countries, Malawi and Tanzania, the ANC surveillance survey estimates were higher than the DHS/AIS estimates for women in the catchment areas who received ANC for their last birth; in another two countries, Ethiopia and Kenya, the ANC surveillance survey estimates were lower; and in Uganda the two estimates were the same.

ANC surveillance surveys also provide estimates of HIV prevalence by age, urban/rural residence, and education categories. However, these breakdowns were not available by age for Kenya and by education for Ethiopia. By age groups, in all four countries with available data, younger women (age 15-24) in the ANC catchment areas of DHS/AIS samples had lower HIV prevalence than younger women in the ANC surveillance surveys (Table 5). This pattern reverses for older age groups, with women age 25 and older in the ANC catchment areas of DHS/AIS surveys having higher HIV prevalence than those in the ANC surveillance surveys. This finding suggests that women covered by ANC

surveillance sites are not representative of all women even within the 15 km catchment areas of the surveillance sites. However, this differential age pattern in HIV prevalence between the two data sources largely disappears when a comparison is made with women from the DHS/AIS surveys who lived in the 15 km catchment areas of the ANC surveillance sites and received ANC for their last birth in the three years preceding the survey.

<Table 5 about here>

The total ANC prevalence estimates are generally closer to the urban ANC estimates, suggesting some over-representation of urban women in ANC surveillance surveys. In Both the ANC surveillance surveys and in the ANC catchment areas of the DHS/AIS surveys, urban women have higher HIV prevalence than rural women, but there are no consistent patterns in the urban/rural differential between the two data sources. By education categories also there are no consistent patterns within or between the two data sources.

Effects of non-response in the surveys

Response rates and reasons for non-response

Table 6 shows the response rates for household interview and individual interview. Household response rates were very high in all surveys, 93% or higher in all 14 countries. Response rates for individual interview were also above 90% in most surveys. Individual interview response rates for females ranged from 90% in Cote d'Ivoire and Zimbabwe to 98% in Rwanda. Individual interview response rates for males were lower than for females in all 14 countries. Response rates for male individual interview ranged from a low of 82% in Zimbabwe to 97% in Rwanda.

<Table 6 about here>

Table 6 also shows numbers of males and females eligible for HIV testing and the response rates for HIV testing. Response rates for HIV testing were lower than those for individual interview in all cases. In 7 of the 14 countries, the difference in the response rates for individual interview and for HIV testing was greater than 10 percentage points for both males and females. The highest differences were observed in the case of Malawi, where the response rate for HIV testing was 23 percentage points lower for males and 25 percentage points lower for females than the corresponding response rates for individual interview. On the other hand, Rwanda stood out as having the smallest differences in the individual interview and HIV testing response rates (2 percentage points for males and 1 percentage point for females).

Response rates for HIV testing for males were lowest in Malawi and Zimbabwe, where only 63% of eligible males were tested. Male HIV response rates were also relatively low in Lesotho (68%) and Kenya (70%). The highest male HIV response rates were in

Rwanda (96%), followed by Cambodia and Cameroon (90% each). As with individual interview response rates, HIV response rates for females were considerably higher than for males in all countries. The lower response rates for males mainly reflect more frequent and longer absence of men from the households. Female HIV response rates ranged from 70% in Malawi to 97% in Rwanda. HIV response rates for females were above 90% also in Cameroon, Burkina Faso, and Cambodia.

Table 7 shows the distribution of eligible males and females by HIV testing status and by interview status. In several countries, there were a small number of adults who were not interviewed but they were tested for HIV. These proportions were less than 1% in most cases, except in Burkina Faso and Cameroon. In some countries (Cote d'Ivoire, India, Malawi, Tanzania, and Zimbabwe), the survey protocol did not allow for the possibility of testing without individual interview.

<Table 7 about here>

Among females who were not tested for HIV, the proportion who were interviewed but not tested was greater than the proportion who were not interviewed and not tested in all countries, except Cambodia and Rwanda. However, among non-tested males, the proportion who were not interviewed and not tested was greater than proportion who were interviewed and not tested in 7 of the 14 countries. In most countries, the proportion interviewed and not tested among males was similar or slightly higher to that among females, with the notable exceptions of Ghana and Rwanda where this proportion was considerably higher among males. Whereas the proportion not interviewed and not tested was much greater among males than among females in all 14 countries, mainly reflecting greater absence of men for participation in the survey.

Table 8 shows HIV non-response rates by reasons for non-response. For female non-respondents, refusal was a more important reason for non-response than absence in all countries, except Rwanda where very few women refused HIV testing. For male non-responders also, refusal was a more important reason than absence in 9 of the 14 countries. Again in Rwanda, very few men refused HIV testing.

In all 14 countries, men were much more likely than women to be absent for testing. In 12 of the 14 countries, the HIV non-response rate due to absence was 2-4-times greater for men than for women. Men were also somewhat more likely than women to refuse testing in 9 of the 14 countries, but about equally likely or somewhat less likely than women in the remaining 5 countries.

<Table 8 about here>

Non-response rates for HIV testing also varied widely by various socio-demographic and behavioral characteristics of the respondents. Non-response rates due to both refusal and absence were much higher in urban areas than in rural areas. Also, the non-response rates were considerably higher among more-educated and wealthier respondents. These patterns of non-response are typical of most household surveys in developing countries.

There were no clear patterns in the HIV non-response rates by various risk and protective factors (data not shown).

Non-response rates among chronically-ill adults

Table 9 compares HIV response rates among chronically ill adults with those among non-chronically ill adults in eight countries with available data on chronic illness status (ill for three or more months in the past year). In 5 of the 8 countries, the response rates were slightly higher among chronically ill adults than among adults who were not chronically ill. This suggests that differential participation of chronically ill adults is unlikely to be a major source of bias.

<Table 9 about here>

Estimated effects of non-response bias

Table 10 shows how the predicted HIV prevalence among non-responders differs from the observed HIV prevalence among tested respondents, and what impact this non-response bias has on the adjusted prevalence estimate for all eligible respondents.

In most countries, non-tested males and females have higher predicted HIV prevalence than the observed prevalence among those who were tested. In 7 of the 14 countries for males and in 5 of the 14 countries for females, the predicted prevalence among non-tested is significantly greater than the observed prevalence among those tested. In Uganda for both males and females and in Kenya for females, the predicted prevalence among the non-tested is significantly lower than among those tested.

<Table 10 about here>

Adjusting the observed national HIV estimates from tested males and females by accounting for the predicted rates among the non-responders makes little difference to the observed estimates in most cases. Even in countries where predicted prevalence among the non-responders is significantly higher or lower, the adjusted prevalence for all eligible respondents is about the same as the observed prevalence based only on the tested respondents. The small effects of the non-response bias on the observed national estimates are due to a much smaller proportion of non-responders than those who were tested.

Effects of exclusion of non-household population in the surveys

Our simulation analyses of potential impact of exclusion of non-household population groups on the HIV prevalence estimates from the surveys in India and Cambodia is presented in Tables 11 and 12. In India, the observed national HIV prevalence estimate for adults age 15-49 (males and females combined) was 0.28% and the non-response-adjusted estimate was 0.29%. Correspondingly in Cambodia, the observed estimate

among adults age 15-49 was 0.62% and the non-response-adjusted estimate was 0.64%. For evaluating the impact of exclusion of non-household population, we used the non-response-adjusted estimates of national HIV prevalence among all eligible adults in each country.

In India, under Scenario B where the proportion of adults age 15-49 in the non-household population is assumed to be 67% and the HIV prevalence among non-household adults is assumed to be 10-times that of the non-response-adjusted prevalence among household adults (2.93%), the estimated HIV prevalence among all adults increases to 0.32% (Table 11). Under Scenario C where the proportion of adults age 15-49 in the non-household population is assumed to be 75% and the HIV prevalence among non-household adults is assumed to be 20-times that of the non-response-adjusted prevalence among household adults (5.86%), the estimated HIV prevalence among all adults increases to 0.37%.

<Tables 11 about here>

In Cambodia, under Scenario B where the proportion of adults age 15-49 in the non-household population is assumed to be 67% and the HIV prevalence among non-household adults is assumed to be 10-times that of the non-response-adjusted prevalence among household adults (6.40%), the estimated HIV prevalence among all adults increases to 0.80% (Table 12). Under Scenario C where the proportion of adults age 15-49 in the non-household population is assumed to be 75% and the HIV prevalence among non-household adults is assumed to be 20-times that of the non-response-adjusted prevalence among household adults (12.80%), the estimated HIV prevalence among all adults increases to 1.01%.

<Tables 12 about here>

CONCLUSIONS

Most countries with generalized epidemics generate HIV prevalence data from antenatal-clinic based surveillance systems. The primary purpose of surveillance systems is to track trends, but they have also been used extensively to estimate levels (Stover et al. 2004). The limitations of such data are well-known, including the underrepresentation of remote rural populations in clinic-based systems, the lack of data on men and non-pregnant women and the limited ability to assess risk factors (Boerma et al. 2003). The added value of population-based surveys is primarily the provision of direct data on the distribution of HIV infection among the general adult population, remote rural populations, men, young non-pregnant women, and regions or provinces.

Our analysis of a comparison of HIV prevalence estimates from ANC surveillance surveys and the DHS/AIS surveys in five countries in sub-Saharan Africa suggests that HIV prevalence estimates derived from ANC surveillance surveys tend to overestimate HIV prevalence among women in the general population. However, the DHS/AIS estimates compare well with the ANC surveillance estimates when the comparison is

restricted to women residing within the catchment areas of the ANC surveillance sites. Patterns by age and urban/rural residence point to possible sources of bias in the ANC estimates.

Our analysis of non-response bias indicated that although non-tested males and females tend to have higher predicted HIV prevalence than those tested, overall effects of non-response on the observed national HIV prevalence estimates are insignificant.

Finally, our analysis of potential bias in the national HIV prevalence estimates due to exclusion of non-household population in two countries indicated that exclusion of non-household population groups in the surveys is likely to have only a minimal effect on the observed HIV prevalence estimates.

There are several limitations of this analysis which should be kept in mind when interpreting the findings:

A major limitation is that our selection of clusters within a 15 kilometer radius around the ANC surveillance sites was based on the assumption that 15 kilometer is a reasonable maximum distance which women would travel for ANC, yet it may not reflect a true catchment area for an ANC site. A previous analysis of ANC attendees at sentinel surveillance sites in Uganda showed that these distances correspond reasonably well with the actual administrative areas where clients were living (Musinguzi et al. 2007). Moreover, the distance women travel for ANC in a country may vary from one region to another and may be different for urban and rural areas. For a more meaningful comparison, the catchment areas should be defined by examining the ANC client records for each surveillance site.

Another source of bias may be due to displacement of GPS coordinates of survey clusters (5 kilometer in rural areas and 2 kilometer in urban areas) to protect confidentiality of survey participants. However, because the displacement was random and the results from individual ANC catchment areas were aggregated up to the national level, any effect of such bias is expected to be small. The comparison between the ANC surveillance survey and the surveys may also be affected by differences in HIV testing protocol, and differences in the definitions of urban and rural areas.

In the analysis of the non-response bias, a limitation is that the estimates are only adjusted to the extent that the socio-demographic and behavioral characteristics included in the analysis are correlated with the risk of HIV infection. Another limitation is that the adjustments for respondents “not interviewed, not tested” are based on limited information available from the household questionnaire.

Despite these limitations, our analysis suggests that population-based surveys have provided reliable, nationally-representative direct estimates of HIV seroprevalence in countries with generalized epidemics. These data are useful for identifying geographic areas of elevated HIV infection; higher-risk and vulnerable populations; understanding risky behaviors; assessing availability and access to HIV-related health services; and

planning for prevention, care and support, and treatment programs. Furthermore, HIV prevalence data from population-based can be useful in calibrating estimates from sentinel surveillance.

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Table 1. UNAIDS and DHS/AIS estimates of HIV prevalence among adults aged 15-49 in selected countries, 2003-2005

	UNAIDS			DHS	UNAIDS/DHS Ratio		
Country	**2001**	**2003**	**2005**	**2001-05**	**2001**	**2003**	**2005**
Burkina Faso 2003	6.5	4.2	2.0	1.8	3.6	2.3	1.1
Cameroon 2004	11.8	6.9	5.4	5.5	2.1	1.3	1.0
Dom. Rep. 2002	2.5	1.7	1.1	1.2	2.1	1.4	0.9
Ghana 2003	3.0	3.1	2.3	2.2	1.4	1.4	1.0
Guinea 2005	NA	3.2	1.5	1.5	NA	2.1	1.0
Kenya 2003	15.0	6.7	6.1	6.7	2.2	1.0	0.9
Lesotho 2004	31.0	29.3	23.2	23.5	1.3	1.2	1.0
Malawi 2004	15.0	14.2	14.1	11.8	1.3	1.2	1.2
Rwanda 2005	8.9	5.1	3.1	3.0	3.0	1.7	1.0
Tanzania 2003-04	7.8	9.0	6.5	7.0	1.1	1.3	0.9
Uganda 2004-05	5.0	4.1	6.7	6.4	0.8	0.6	1.0
Zambia 2001-02	21.5	16.5	17.0	15.6	1.4	1.1	1.1

Table 2. Observed HIV prevalence by sex and urban/rural residence, DHS/AIS countries with HIV testing

Country/sex	Observed HIV prevalence		
	Urban	Rural	Total
Burkina Faso 2003			
Male (15-59)	3.6	1.4	1.9
Female (15-49)	4.0	1.2	1.8
Total (15-49)	3.5	1.3	1.8
Cambodia 2005			
Male (15-49)	1.6	0.4	0.6
Female (15-49)	1.3	0.5	0.6
Total (15-49)	1.4	0.4	0.6
Cameroon 2004			
Male (15-59)	4.7	2.8	3.9
Female (15-49)	8.4	4.8	6.8
Total (15-49)	6.7	4.0	5.5
Cote d'Ivoire 2005			
Male (15-49)	3.2	2.5	2.9
Female (15-49)	7.4	5.5	6.4
Total (15-49)	5.4	4.1	4.7
Ethiopia 2005			
Male (15-59)	2.6	0.6	0.9
Female (15-49)	7.7	0.7	1.9
Total (15-49)	5.5	0.7	1.4
Ghana 2003			
Male (15-59)	1.7	1.7	1.7
Female (15-49)	2.9	2.5	2.7
Total (15-49)	2.3	2.0	2.2
India 2005/06			
Male (15-54)	0.4	0.3	0.4
Female (15-49)	0.3	0.2	0.2
Total (15-49)	0.4	0.3	0.3
Kenya 2003			
Male (15-54)	7.8	3.7	4.7
Female (15-49)	12.3	7.5	8.7
Total (15-49)	10.2	5.6	6.8
Lesotho 2004			
Male (15-59)	22.2	18.1	18.9
Female (15-49)	33.0	24.3	26.4
Total (15-49)	28.9	21.6	23.2
Malawi 2004			
Male (15-54)	16.4	8.9	10.2
Female (15-49)	18.0	12.5	13.3
Total (15-49)	17.1	10.8	11.8
Rwanda 2005			
Male (15-59)	5.6	1.5	2.2
Female (15-49)	8.6	2.6	3.6
Total (15-49)	7.3	2.2	3.1
Tanzania 2003			
Male (15-49)	9.6	4.8	6.3
Female (15-49)	12.0	5.8	7.7
Total (15-49)	10.9	5.4	7.0
Uganda 2004/05			
Male (15-59)	6.9	4.9	5.2

Female (15-59)	12.6	6.4	7.3
Total (15-49)	10.1	5.7	6.4
Zimbabwe 2005/06			
Male (15-54)	16.0	13.9	14.8
Female (15-49)	21.6	20.8	21.1
Total (15-49)	18.9	17.6	18.1

Table 3. Comparison of HIV prevalence among women age 15-49 from the DHS/AIS and from ANC sentinel surveillance

	Data sources				HIV prevalence					
	DHS/AIS		ANC		Urban		Rural		Total	
	Number	Year	Number	Year	DHS/AIS	ANC	DHS/AIS	ANC	DHS/AIS	ANC
Ethiopia	5,736	2005	28,247	2005	7.7	9.5	0.7	2.2	1.9	5.3
Kenya	3,285	2003	9.773	2004	12.3	8.9	7.5	6.4	8.7	7.5 [a]
Malawi	2,864	2004	8,953	2005	18.0	20.4	12.5	13.0	13.3	16.9
Tanzania	5,973	2003-04	17,813	2003-04	12.0	11.4	5.8	3.4	7.7	8.7
Uganda	9,391	2004-05	9,668	2005	12.8	7.6	6.5	5.3	7.5	6.0

[a]Kenya separates Nairobi, where SS 2004 prevalence is estimated at 10.9% (114/1042). The estimated prevalence in urban/peri-urban excluding Nairobi is 8.2% (267/3241). The estimated prevalence in urban/peri-urban + Nairobi is 8.9% ((114+267)/(1042+3241))

Table 4. Comparison of HIV prevalence among women age 15-49 from ANC sentinel surveillance and DHS/AIS surveys in selected coutries, 2003-05

	ANC	DHS/AIS			
		All women (weighted)		Women who live in a community within 15km from the nearest ANC site (unweighted)	
	%	%	n	%	n
Ethiopia					
Total	**5.3**	1.9	5,729	4.3	1,911
Currently pregnant					
No		1.9	5,250	4.5	1,810
Yes		1.1	479	2.0	101
Gave birth in last 3 years					
No		2.0	3,305	4.7	1,417
Yes		1.7	2,423	3.2	494
Attended ANC for last birth in last 3 years					
No ANC/no birth in last 3 years		1.6	5,099	4.1	1,681
Birth in last 3 years with ANC		3.7	630	6.5	230
Kenya					
Total	**7.5**	8.7	3,151	9.8	1,178
Currently pregnant					
No		8.8	2,891	9.8	1,100
Yes		7.3	260	9.0	78
Gave birth in last 3 years					
No		8.8	1,961	10.0	823
Yes		8.5	1,190	9.3	355
Attended ANC for last birth in last 3 years					
No ANC/no birth in last 3 years		8.6	2,081	9.8	855
Birth in last 3 years with ANC		8.9	1,070	9.6	323
Malawi					
Total	**16.9**	13.3	2,686	18.5	736
Currently pregnant					
No		13.9	2,323	19.0	636
Yes		9.8	362	15.0	100
Gave birth in last 3 years					
No		16.6	1,282	23.1	390
Yes		10.4	1,404	13.3	346
Attended ANC for last birth in last 3 years					
No ANC/no birth in last 3 years		16.3	1,337	22.8	399
Birth in last 3 years with ANC		10.4	1,349	13.4	337
Tanzania					
Total	**8.7**	7.7	5,753	8.6	1,194

Currently pregnant					
No		7.8	5,210	8.4	1,117
Yes		6.8	533	11.7	77
Gave birth in last 3 years					
No		9.1	3,206	9.5	777
Yes		6.0	2,547	6.9	418
Attended ANC for last birth in last 3 years					
No ANC/no birth in last 3 years		8.7	3,558	9.5	813
Birth in last 3 years with ANC		6.0	2,195	6.8	382
Uganda					
Total	**6.0**	7.5	9,391	8.0	2,371
Currently pregnant					
No		7.7	8,250	8.0	2,125
Yes		6.5	1,068	8.7	231
Gave birth in last 3 years					
No		8.5	4,895	9.2	1,392
Yes		6.4	4,496	6.2	979
Attended ANC for last birth in last 3 years					
No ANC/no birth in last 3 years		8.5	5,526	9.1	1,509
Birth in last 3 years with ANC		6.1	3,866	6.0	862

Table 5. Comparison of HIV prevalence among women age 15-49 from ANC sentinel surveillance and the DHS/AIS survey who gave birth in last 3 years and attended ANC in a public facility in selected coutries, 2003-05 (unweighted)

	Ethiopia			Kenya			Malawi			Tanzania			Uganda		
	DHS/AIS 15km catchment area	Attended ANC DHS/AIS 15km catchment area	ANC	DHS/AIS 15km catchment area	Attended ANC DHS/AIS 15km catchment area	ANC	DHS/AIS 15km catchment area	Attended ANC DHS/AIS 15km catchment area	ANC	DHS/AIS 15km catchment area	Attended ANC DHS/AIS 15km catchment area	ANC	DHS/AIS 15km catchment area	Attended ANC DHS/AIS 15km catchment area	ANC
Total	4.3	6.5	5.3	9.8	9.6	7.5	18.5	13.4	16.9	8.6	6.8	8.7	8.0	6.0	6.0
Age															
15-24	2.5	7.7	5.6	6.0	6.4	NA	11.8	10.2	14.3	2.6	2.8	7.4	4.5	6.5	5.0
25-34	6.0	6.0	5.4	14.7	13.2	NA	24.7	16.8	21.2	12.9	9.4	11.0	11.4	6.6	7.9
35-49	6.0	5.7	3.3	10.4	7.7	NA	22.2	13.2	16.9	13.2	8.8	6.7	10.1	2.6	4.0
Residence															
Urban	5.9	7.4	9.5	12.5	14.2	8.9	20.6	19.5	18.3	11.0	9.6	11.4	12.3	11.3	7.6
Rural	1.5	4.9	2.2	6.4	5.0	6.4	17.6	11.2	13.0 [a]	5.1	3.8	3.4	3.3	2.0	5.3
Education															
None	3.2	3.1	NA	6.7	NA	NA	21.3	12.7	17.9	8.2	3.5	5.2	6.9	6.5	3.9
Primary	4.6	6.7	NA	11.7	11.4	NA	17.2	12.3	16.1	9.0	7.2	9.3 [b]	8.4	5.8	4.8
Secondary+	5.5	10.3	NA	8.0	7.9	NA	19.6	19.2	33.3	7.6	9.1	NA	7.8	6.2	6.1

[a] includes urban and semi-urban

[b] some education is the only category in the report

Note: ANC estimates by education for Uganda seem inconsistent with total ANC estimate. Need to be checked with MOH Uganda.

Table 6. Response rates for individual interview and for HIV testing by sex, DHS/AIS countries with HIV testing

Country sex (age)	Household response rate	Individual response rate	Number eligible for HIV testing	HIV response rate
Burkina Faso 2003	99.4			
Male (15-59)		90.5	3,984	85.8
Female (15-49)		96.7	4,575	92.3
Cambodia 2005	98.0			
Male (15-49)		93.1	7,229	90.3
Female (15-49)		97.2	8,638	95.1
Cameroon 2004	97.6			
Male (15-59)		93.0	5,676	89.8
Female (15-49)		94.5	5,703	92.1
Cote d'Ivoire 2005	95.5			
Male (15-49)		87.5	5,148	75.8
Female (15-49)		89.8	5,772	78.7
Ethiopia 2005	98.6			
Male (15-59)		89.0	6,778	75.4
Female (15-49)		95.4	7,142	83.2
Ghana 2003	98.7			
Male (15-59)		93.8	5,345	80.0
Female (15-49)		95.7	5,949	89.3
India 2005/06				
Male (15-54)	92.85	86.49	64,175	78.1
Female (15-49)		93.62	62,182	85.0
Kenya 2003	96.3			
Male (15-54)		85.5	4,183	70.3
Female (15-49)		94.0	4,303	76.3
Lesotho 2004	97.4			
Male (15-59)		84.6	3,305	68.0
Female (15-49)		94.2	3,758	80.7
Malawi 2004	97.8			
Male (15-54)		85.9	3,797	63.3
Female (15-49)		94.9	4,071	70.4
Rwanda 2005	99.6			
Male (15-59)		97.2	4,959	95.6
Female (15-49)		98.1	5,837	97.3
Tanzania 2003	98.5			
Male (15-49)		91.3	6,196	77.1
Female (15-49)		95.9	7,154	83.5
Uganda 2004/05	96.8			
Male (15-59)		89.1	9,905	83.8
Female (15-59)		94.5	11,454	89.3
Zimbabwe 2005/06	95.0			
Male (15-54)		81.9	8,761	63.4
Female (15-49)		90.2	9,870	75.9

Table 7. Distribution of eligible males and females by interview status and HIV testing status, DHS/AIS countries with HIV testing

Country/sex	Number eligible	Tested		Not tested	
		Interviewed	Not interviewed	Interviewed	Not interviewed
Burkina Faso 2003					
Male (15-59)	3,984	83.9	1.9	6.6	7.6
Female (15-49)	4,575	91.6	0.7	5.1	2.6
Cambodia 2005					
Male (15-49)	7,229	90.1	0.2	3.0	6.7
Female (15-49)	8,638	94.8	0.3	2.4	2.4
Cameroon 2004					
Male (15-59)	5,676	88.9	1.0	4.2	6.0
Female (15-49)	5,703	90.4	1.7	4.1	3.7
Cote d'Ivoire 2005					
Male (15-49)	5,148	75.8	n/a	11.7	12.5
Female (15-49)	5,772	78.7	n/a	11.1	10.2
Ethiopia 2005					
Male (15-59)	6,778	75.2	0.2	13.8	10.8
Female (15-49)	7,142	83.0	0.2	12.4	4.5
Ghana 2003					
Male (15-59)	5,345	79.8	0.1	14.0	6.0
Female (15-49)	5,949	89.0	0.2	6.6	4.1
India 2005/06					
Male (15-54)	64,175	78.1	n/a	8.4	13.5
Female (15-49)	62,182	85.0	n/a	8.6	6.4
Kenya 2003					
Male (15-54)	4,183	69.7	0.6	15.8	13.9
Female (15-49)	4,303	76.1	0.3	17.9	5.8
Lesotho 2004					
Male (15-59)	3,305	67.6	0.4	17.0	15.0
Female (15-49)	3,758	80.4	0.3	13.8	5.5
Malawi 2004					
Male (15-54)	3,797	63.3	n/a	22.6	14.1
Female (15-49)	4,071	70.4	n/a	24.6	5.1
Rwanda 2005					
Male (15-59)	4,959	95.3	0.3	1.9	2.5
Female (15-49)	5,837	97.0	0.2	1.1	1.6
Tanzania 2003					
Male (15-49)	6,196	77.1	n/a	14.3	8.7
Female (15-49)	7,154	83.5	n/a	12.4	4.1
Uganda 2004/05					
Male (15-59)	9,905	83.4	0.4	5.8	10.4
Female (15-59)	11,454	88.9	0.4	5.7	5.1
Zimbabwe 2005/06					
Male (15-54)	8,761	63.4	n/a	18.5	18.1
Female (15-49)	9,870	75.9	n/a	14.3	9.8

Table 8. Reasons for HIV non-response by sex, DHS/AIS countries with HIV testing

Country/sex	HIV non-response rate	Reason for HIV non-response		
		Refused	Absent	Other/ missing
Burkina Faso 2003				
Male (15-59)	14.2	5.9	5.1	3.2
Female (15-49)	7.7	4.0	2.0	1.7
Cambodia 2005				
Male (15-49)	9.7	3.7	5.1	0.9
Female (15-49)	4.9	2.7	1.5	0.6
Cameroon 2004				
Male (15-59)	10.2	5.2	3.5	1.5
Female (15-49)	7.9	5.1	1.5	1.3
Cote d'Ivoire 2005				
Male (15-49)	24.2	13.9	9.2	1.1
Female (15-49)	21.3	14.5	5.2	1.6
Ethiopia 2005				
Male (15-59)	24.7	15.0	7.8	1.9
Female (15-49)	16.8	13.3	2.3	1.3
Ghana 2003				
Male (15-59)	20.0	10.3	7.5	2.2
Female (15-49)	10.7	5.3	3.7	1.8
India 2005/06				
Male (15-54)	21.9	6.9	12.1	3.0
Female (15-49)	15.0	8.1	4.5	2.4
Kenya 2003				
Male (15-54)	29.7	12.8	13.9	2.9
Female (15-49)	23.7	14.5	6.3	2.8
Lesotho 2004				
Male (15-59)	32.0	16.6	8.7	6.8
Female (15-49)	19.3	12.1	2.9	4.3
Malawi 2004				
Male (15-54)	36.7	24.6	9.3	2.8
Female (15-49)	29.7	24.0	2.5	3.1
Rwanda 2005				
Male (15-59)	4.4	0.4	3.3	0.8
Female (15-49)	2.7	0.3	2.0	0.5
Tanzania 2003				
Male (15-49)	23.0	14.9	7.0	1.1
Female (15-49)	16.5	12.9	2.8	0.8
Uganda 2004/05				
Male (15-59)	16.2	5.8	8.8	1.6
Female (15-59)	10.7	5.2	4.0	1.6
Zimbabwe 2005/06				
Male (15-54)	36.6	21.0	12.9	2.7
Female (15-49)	24.1	15.3	6.4	2.3

[a] Absent and other categories combined

[b] Includes only missing cases

[c] Includes all non-interviewed

Table 9. HIV response rates among chronically ill adults, by sex, interview status and HIV testing status, DHS/AIS countries with HIV testing

Country/sex	Data availability (age range)	Number of chronically ill adults	HIV response rate	Tested		Not tested		Reason for HIV non-response		
				Interviewed	Not interviewed	Interviewed	Not interviewed	Refused	Absent	Other/ missing
Cambodia 2005										
Male (15-49)		107	90.7	90.7	0.0	0.0	9.4	5.6	0.0	3.7
Female (15-49)	15+	152	95.4	94.7	0.7	2.6	2.0	2.0	0.0	2.6
Cameroon 2004										
Male (15-59)		351	92.0	90.0	2.0	2.9	5.1	2.3	4.0	1.7
Female (15-49)	15-59	375	93.6	89.9	3.7	2.7	3.7	1.9	0.3	1.3
Cote d'Ivoire 2005										
Male (15-49)		63	76.2	76.2	n/a	7.9	15.9	7.9	15.9	0.0
Female (15-49)	18-59	58	81.0	81.0	n/a	12.1	6.9	12.1	6.9	0.0
Malawi 2004										
Male (15-54)		148	62.2	62.2	n/a	16.9	21.0	16.9	21.0	0.0
Female (15-49)	5-54	207	67.2	67.2	n/a	25.1	7.7	21.7	7.7	3.4
Rwanda 2005										
Male (15-59)		181	93.4	92.8	0.6	0.6	6.1	0.6	4.4	1.7
Female (15-49)	18-59	225	95.1	93.8	1.3	1.3	3.6	0.4	3.6	0.9
Tanzania 2003										
Male (15-49)		124	82.3	82.3	n/a	10.5	7.3	9.7	7.3	0.8
Female (15-49)	0-59	156	83.3	83.3	n/a	8.3	8.3	8.3	8.3	0.0
Uganda 2004/05										
Male (15-59)		326	91.1	89.3	1.8	3.7	5.2	2.8	4.0	2.2
Female (15-59)	18-59	367	92.4	91.6	0.8	4.6	3.0	4.1	3.0	0.5
Zimbabwe 2005/06										
Male (15-54)		165	61.2	61.2	n/a	15.2	23.6	14.6	23.6	0.6
Female (15-49)	18-59	233	76.8	76.8	n/a	12.9	10.3	12.5	10.3	0.4

Table 10. Predicted HIV prevalence among the non-respondents and adjusted HIV prevalence estimate for all eligible males and females, DHS/AIS countries with linked HIV testing data

Country	Observed HIV prevalence among tested respondents	Predicted HIV prevalence among non-tested respondents						Adjusted prevalence among all eligible respondents
		Interview status		Reason not tested				
		Inter-viewed	Not inter-viewed	Refused	Absent	Other/ missing	Total non-tested	
Burkina Faso 2003								
Male (15-59)	1.94	2.68	2.48	2.91	2.52	2.11	2.57 *	2.02
Female (15-49)	1.83	3.56	2.30	3.71	2.35	2.78	3.15 *	1.94
Cambodia 2005								
Male (15-49)	0.62	1.07	0.79	1.09	0.82	0.38	0.88	0.64
Female (15-49)	0.61	1.49	0.61	1.41	0.54	0.53	1.02	0.63
Cameroon 2004								
Male (15-59)	3.91	5.17	5.10	5.44	5.00	3.71	5.13 *	4.04
Female (15-49)	6.75	8.73	8.24	8.72	8.87	7.12	8.51 *	6.90
Cote d'Ivoire 2005								
Male (15-49)	2.86	3.39	3.21	3.22	3.48	2.29	3.29	2.98
Female (15-49)	6.40	6.89	7.73	7.15	7.93	6.05	7.29 *	6.64
Ethiopia 2005								
Male (15-59)	0.92	1.44	1.23	1.44	1.30	0.87	1.34 *	0.99
Female (15-49)	1.86	3.46	3.23	3.50	4.07	1.62	3.39 *	2.06
Ghana 2003								
Male (15-59)	1.66	2.14	1.62	2.27	1.50	2.40	1.98	1.72
Female (15-49)	2.70	2.97	2.46	3.10	2.40	2.56	2.77	2.70
India 2005/06								
Male (15-54)	0.35	0.44	0.53	0.44	0.51	0.58	0.50 *	0.38
Female (15-49)	0.22	0.25	0.32	0.24	0.30	0.36	0.28 *	0.23
Kenya 2003								
Male (15-54)	4.71	4.47	5.81	4.83	5.54	4.28	5.11	4.81
Female (15-49)	8.70	6.82	9.24	7.19	8.00	7.59	7.46 *	8.45
Lesotho 2004								
Male (15-59)	18.94	19.12	19.18	18.94	18.32	20.66	19.15	19.01
Female (15-49)	26.37	25.17	24.54	25.70	23.80	23.72	25.00	26.09
Malawi 2004								
Male (15-54)	10.23	9.53	11.37	9.44	12.74	9.31	10.20	10.22
Female (15-49)	13.32	12.14	12.68	12.02	13.01	13.28	12.24	12.99
Rwanda 2005								
Male (15-59)	2.24	3.00	3.16	4.42	2.87	3.26	3.09 *	2.28
Female (15-49)	3.61	5.74	3.84	5.21	4.53	4.75	4.64	3.64
Uganda 2004/05								
Male (15-59)	5.15	3.88	4.52	3.87	4.41	5.16	4.28 *	5.03
Female (15-59)	7.29	6.24	7.01	6.58	6.86	5.92	6.58 *	7.22
Tanzania 2003								
Male (15-49)	6.26	6.84	7.38	6.99	7.37	5.45	7.04 *	6.44
Female (15-49)	7.70	8.40	7.20	8.36	7.29	6.94	8.11	7.77
Zimbabwe 2005/06								
Male (15-54)	14.75	15.28	17.38	15.79	16.67	19.05	16.35 *	15.28
Female (15-49)	21.12	19.90	21.38	20.06	21.48	20.71	20.51	20.97

Table 11. Possible effects of exclusion of non-household population on the national HIV estimate for adults age 15-49, India 2005/06

	Source: 2001 India Census								
	Population in 2001	Annual growth rate	Population in 2006	% population age 15-49	Projected population age 15-49	HIV prevalence		Number of HIV+ in population 15-49	Estimated HIV prevalence
Scenario A (baseline)									
Population living in households	1,018,863,368	1.63%	1,101,648,431	53.18%	585,804,092	**Survey estimate**	**0.29%**	1,716,406	
Non-household population (houseless and institutional)	9,746,632	1.63%	10,538,569	53.18%	5,603,908	**non-HH estimate = survey estimate**	**0.29%**	16,419	
TOTAL POPULATION OF INDIA	1,028,610,000	1.63%	1,112,187,000	53.18%	591,408,000			1,732,825	**0.29%**
Scenario B									
Population living in households	1,018,863,368	1.63%	1,101,648,431	53.05%	584,381,936	**Survey estimate**	**0.29%**	1,712,239	
Non-household population (houseless and institutional)	9,746,632	1.63%	10,538,569	66.67%	7,026,064	**Non-HH estimate = 10 * survey estimate**	**2.93%**	205,864	
TOTAL POPULATION OF INDIA	1,028,610,000	1.63%	1,112,187,000	53.18%	591,408,000			1,918,103	**0.32%**
Scenario C									
Population living in households	1,018,863,368	1.63%	1,101,648,431	52.97%	583,504,073	**Survey estimate**	**0.29%**	1,709,667	
Non-household population (houseless and institutional)	9,746,632	1.63%	10,538,569	75.00%	7,903,927	**Non-HH estimate = 20 * survey estimate**	**5.86%**	463,170	
TOTAL POPULATION OF INDIA	1,028,610,000	1.63%	1,112,187,000	53.18%	591,408,000			2,172,837	**0.37%**

Note: In the 2001 Census, the proportion of adults in the houseless population was 56.15%.
Scenario A: Proportion of adults (15-49) in non-household population is SAME as in the national census population (53.18%). Prevalence among non-household adults is SAME as non-response adjusted prevalence for all eligible adults in the survey (0.29%).
Scenario B: Proportion of adults (15-49) in non-household population is 66.67%. Prevalence among non-household adults is 10 times that of non-response adjusted prevalence for all eligible adults in the survey (2.93%).
Scenario C: Proportion of adults (15-49) in non-household population is 75.00%. Prevalence among non-household adults is 20 times that of non-response adjusted prevalence for all eligible adults in the survey (5.86%).

Table 12. Possible effects of exclusion of non-household population on the national HIV estimate for adults age 15-49, Cambodia 2005

	Source: Cambodia Inter-Censal Survey 2004								
	Population in 2004	Annual growth rate	Population in 2005	% population age 15-49	Projected population age 15-49	HIV prevalence		Number of HIV+ in population 15-49	Estimated HIV prevalence
Scenario A (baseline)									
Population living in households	12,824,000	1.81%	13,056,114	50.40%	6,580,282	**Survey estimate**	**0.64%**	42,114	
Non-household population (houseless and institutional)	267,000	1.81%	271,833	50.40%	137,004	**non-HH estimate = survey estimate**	**0.64%**	877	
TOTAL POPULATION OF CAMBODIA	13,091,000	1.81%	13,327,947	50.40%	6,717,285			42,991	**0.64%**
Scenario B									
Population living in households	12,824,000	1.81%	13,056,114	50.06%	6,536,054	**Survey estimate**	**0.64%**	41,831	
Non-household population (houseless and institutional)	267,000	1.81%	271,833	66.67%	181,231	**Non-HH estimate = 10 * survey estimate**	**6.40%**	11,599	
TOTAL POPULATION OF CAMBODIA	13,091,000	1.81%	13,327,947	50.40%	6,717,285			53,430	**0.80%**
Scenario C									
Population living in households	12,824,000	1.81%	13,056,114	49.89%	6,513,411	**Survey estimate**	**0.64%**	41,686	
Non-household population (houseless and institutional)	267,000	1.81%	271,833	75.00%	203,875	**Non-HH estimate = 20 * survey estimate**	**12.80%**	26,096	
TOTAL POPULATION OF CAMBODIA	13,091,000	1.81%	13,327,947	50.40%	6,717,285			67,782	**1.01%**

Scenario A: Proportion of adults (15-49) in non-household population is SAME as in the Inter-Censal population (50.40%). Prevalence among non-household adults is SAME as non-response adjusted prevalence for all eligible adults in the survey (0.64%).
Scenario B: Proportion of adults (15-49) in non-household population is 66.67%. Prevalence among non-household adults is 10 times that of non-response adjusted prevalence for all eligible adults in the survey (6.40%).
Scenario C: Proportion of adults (15-49) in non-household population is 75.00%. Prevalence among non-household adults is 20 times that of non-response adjusted prevalence for all eligible adults in the survey (12.80%).